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Fences Impede Long-distance Mongolian Gazelle (*Procapra gutturosa*) Movements in Drought-stricken Landscapes

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Abstract

Human-generated landscape barriers are especially problematic for species whose life histories entail long-distance movements. In May 2008, hundreds of Mongolian gazelles (*Procapra gutturosa*) became entangled in border fences as thousands attempted to move from Mongolia into Russia. Typically, the root cause of such (non-migratory) mass animal movements can only be superficially described. Here we draw upon satellite imagery and a fortuitously timed field study to investigate a likely hypothesis. At the same time that gazelles were attempting to cross from Mongolia into Russia, gazelles equipped with satellite-linked collars repeatedly attempted to emigrate from Mongolia into China. Satellite-derived estimates of vegetation productivity demonstrate that a decade-long decline in available green biomass in Mongolia's steppes underlies the gazelles' attempted mass emigrations. Given the potential that this trans-boundary movement event will occur within these drought-stricken landscapes in the future, modest fence modifications suitable for other similar open habitat ungulates may be sufficient to allow the gazelles to maintain their nomadic movements.

Key words: Mongolian gazelle, grassland, NDVI, habitat fragmentation, barrier, unsustainable development

Introduction

The impact of fencing on the ability of wildlife to access crucial habitat can have devastating affects and have the potential to severely reduce their numbers, prevent population recovery, and cause economic damage (Bies, 2007; Cohn, 2007; Harrington & Connover, 2006; Ringrose *et al*., 1997; Williamson & Mbano, 1983). Animal species whose life histories entail long-distance movements may be especially sensitive to habitat fragmentation and associated human-generated barriers to movement (Berger, 2004). Effective conservation of such species will require integrative approaches that blend science and public policy, such as a willingness to accommodate trans-boundary animal movements and extensive movements across a multi-use landscape (Bolger *et al*., 2008).

Mongolia's eastern steppes are one of the largest remaining temperate grasslands. Mongolian gazelles (*Procapra gutturosa*), which still persist in large numbers (~1 million individuals [Schaller, 1998, Olson *et al*., 2005]), are the dominant large wild herbivores inhabiting the steppe. These gazelles consistently exhibit long-distance, nomadic movements (our data indicate as much as 600 km from the farthest points in a 12-month period), which rank them among the top five most mobile ungulates (Berger, 2004).

In May 2008, scientists from World Wildlife Fund-Russia, WWF-Mongolia, and the Large Herbivore Foundation reported hundreds of dead Mongolian gazelles entangled in border fences along the Mongolian-Russian border and additional thousands of gazelles trapped between the border fences as they attempted to move from Mongolia into Russia (Large Herbivore Foundation, 2008; World Wildlife Fund, 2008). Attempts were made to facilitate crossing and prevent entanglement

deaths by laying down sections of this fence and herding them through the gaps. Ecological causation for the gazelles' mass movements was not identified which would be helpful in reaching a more permanent solution. Here we examine one hypothesis for such mass movements and suggest modest fence modifications that have been successfully employed for other open habitat ungulates that may be sufficient to allow the gazelles to maintain their life history strategy of nomadic behavior.

Materials and Methods

Mongolian gazelles were reported to be trapped between the parallel fencing delineating the Russian and Mongolian border east of the village of Choolonkhoroot, Mongolia and Solov'evsk, Russia in the first two weeks of May, 2008 (Figure 1). This region consists of parts of what are categorized as the Daurian Steppe and Mongolian-Manchurian Grassland Ecoregions (Olson *et al.*, 2001).

To examine whether the Mongolian gazelles' observed movements from Mongolia towards Russia were driven by a need to locate quality food resources, we analyzed time-series data for available green biomass in two regions of Mongolia's eastern steppes. We used satellite-derived estimates of vegetation productivity evaluated from MODIS 16-day Normalized Difference Vegetation Index (NDVI) composites between May 9 – 24 (the time period when gazelles were observed attempting to cross into Russia) from 2000-2008 (MODIS data became availabile in 2000) (for detailed methods see Mueller *et al.*, 2008). These regions were 1) a 31,000-km^2 area north of the Kherlen River adjacent to the Russian and Chinese borders and extending ~100 km west of the primary entanglement sites, 2) a 53,000-km^2 area south of the Kherlen River delineated as a minimum convex polygon around the locations of collared animals, minus those areas inside China (to which the gazelles did not have access because of extensive fencing), and 3) the entire steppe region defined east of the Trans-Mongolian railroad and the region within the Russian territory relevant to this particular event, a 300,500-km^2 region.

Simultaneously, southeast of the region where the mass entrapments were observed, five Mongolian gazelles fitted with satellite collars with global positioning system (GPS) storage features were being tracked as part of a long term study focusing on ungulate movement ecology (Mueller & Fagan, 2008; Olson *et al.*, 2009).

Results

Over the past nine years, average NDVI estimates of available green biomass in the northern and southern regions have declined by ~37% and 27%, respectively, reaching an absolute low in both cases in 2008 (Figure 1). For the area north of the Kherlen River, available biomass declined on average by 0.01 NDVI units yr^{-1} (r^2=0.73). For the the southern region, available biomass declined on average by 0.008 NDVI units yr^{-1} (r^2=0.64). The NDVI values for the entire region east of the Ulaanbaatar – Beijing railway and in Russia experienced a marginally steeper decline than the corresponding declines calculated for the two smaller regions analyzed (decline rate= 0.006 NDVI units yr^{-1}, r^2=0.59, P = 0.02, F = 9.971).

Our marked animals, all captured in the same location in September 2007, ranged over a 53,000 -km^2 area during the 9-month period prior to this analysis (for comparison, the Serengeti National Park is 25,000 km^2). During this time, in at least four instances (March, April, January, November), we recorded movements by individual gazelles in close proximity of the double-fenced border between Mongolia and China (Figure 1). Usually, after a few days in the immediate vicinity of the fence, animals moved in a different direction from the border. The four border approaches identified were measured to be within 3 and 97 meters from the fence.

After mapping the variations in biomass productivity near the Russia-Mongolia border region where the fence crossing attempts were documented, we noted the presence of a small region along the edge of the Torey Lakes in Russia exhibited higher NDVI values indicating the potential presence of suitable forage (Figure 2). We suggest this flush of green biomass may have been motivating the gazelles' northward movements and attempts to cross the border in that region.

Discussion

Because gazelle presence is tightly linked to

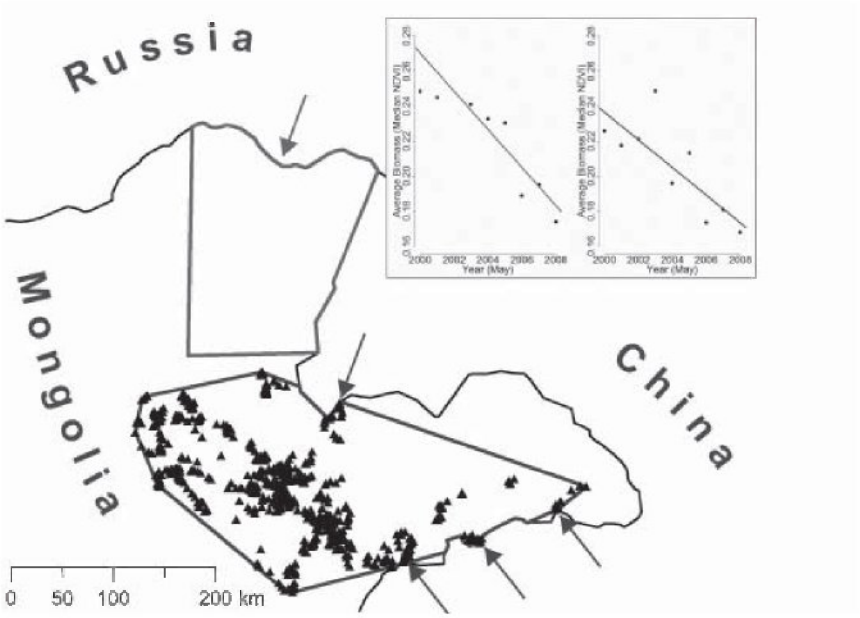

Figure 1. Available green biomass and attempted border crossings by Mongolian gazelles. The red arrow indicates the location of gazelles entangled in border fences while crossing into Russia. Black triangles are relocations of Mongolian gazelles captured in September 2007 and equipped with satellite-linked collars. The blue arrows indicate attempted border crossings of these collared gazelles into China. The inset shows the time series and linear trend of average available green biomass in the northern region (red polygon, $P = 0.004$, $F = 18.58$) and the region encompassing all satellite recaptures of collared animals (blue polygon, $r^2 = 0.64$, $F = 12.22$).

Figure 2. Available green biomass (NDVI) from Modis satellite data in May 2008 in the Mongolian-Russian border region. The red circle delineates the primary area where gazelles moved from Mongolia into Russia. Note the increased NDVI values on the Russian side of the border within this region.

NDVI on both local and regional scales (Olson *et al.*, 2009; Mueller *et al.*, 2008; Leimgruber *et al.*, 2001), the large-scale decline in NDVI appears to be the likely driver behind the gazelles' attempted emigrations. The reason for the declining trends in biomass production observed during the time period in which we conducted our analysis was not examined for this analysis, but long-term chronic drought conditions is a likely cause. Prior to 1999 Mongolia experienced a multi-decadal period of high rainfall appearing to end in 1999 when extreme drought conditions existed throughout Mongolia (Pederson *et al.*, 2001). Pederson *et al.* (2001) noted that drought variations at northern and middle latitudes are more frequent as temperatures become more extreme. Temperature increases is linked to periodic intensification of solar influence and human induced climate change. Regardless of the root cause, it seems reasonable to conclude that this 8-year decline is within the bounds of climatic variation that this system has experienced in the past and that events such as this are likely to occur in the future.

Gazelles have been observed attempting to cross borders from Mongolia into Russia and China in the past (V. Kiriluk, A. Lushchekina, pers. comm.). In both countries, suitable steppe habitat areas for gazelles are relatively small as a consequence of agricultural conversion of grasslands. However, these remaining areas can be critically important in years when conditions in the gazelles' primary range in Mongolia are unfavorable. Additionally, inside Mongolia's border the negative barrier effect of the Trans-Mongolian railway and associated fencing is well documented (Ito *et al.*, 2008; Ito *et al.*, 2005; Reading *et al.*, 1998; Milner-Gulland & Lhagvasuren, 1998; Lhagvasuren & Milner-Gulland, 1997) (Figure 3). Without changes to the structure of the existing fences and policies to minimize new fencing Mongolian gazelles are likely to be entangled in fences again.

In the otherwise continuous expanse of the Mongolian steppes, fences constitute formidable barriers for nomadic gazelles, and unhindered movement for gazelles between these areas should be one of several conservation priorities. In May 2008, Russian border guards temporarily dismantled fences in a good-will gesture that allowed passage for some gazelles. However, for a long-term solution, relatively minor changes to existing wire fences, such as the removal of the bottom strand of wire, lay down fences, or buck and pole fencing may be sufficient to allow Mongolian gazelles to cross and avoid entanglement or prevent access to important forage

Figure 3. Mongolian gazelles attempting to cross and one already successfully crossed a portion of the Trans Mongolian railway fence in Govi Sumber Aimag, Mongolia. The wire strands in this fence are widely spaced and is an injury risk. Mongolian gazelles are able to pass under, but this bottom wire is barbed and is an injury risk. Photo taken by Racheal Barrow.

(Harrington & Connover, 2006; Yoakum, 2004; Scott, 1992; Kindschey *et al*., 1982); however this solution still does not address issues that other larger wild ungulates such as khulan (*Equus hemionus*) face at fence crossings. Similar fence modifications have been successfully used for pronghorn (*Antilocapra americana*) conservation in North America (see State of North Dakota, 2008), and we suggest that fences within the range of the Mongolian gazelle should be assessed to determine where similar adjustments can be made. With similar adjustments, trans-national border fences, as well as railroad fences (Ito *et al*., 2008), may be made more gazelle-friendly while still dissuading movements by livestock and humans.

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Хураангуй

Алс нүүдэллэн амьдардаг зүйлүүдийн хувьд хүний үйл ажиллагаагаар бий болсон байгууламжууд ихээхэн саад хаалт болдог. 2008 оны 5-р сард хэдэн мянгаар тоологдох цагаан зээр (*Procapra gutturosa*) Монголоос ОХУ-ын нутаг руу нэвтрэн орохоор хил орчимд бөөгнөрсний улмаас хэдэн зуун бодгаль хилийн торон хашаанд орооцолдсон байна. Тогтсон нүүдлийн биш амьдралтай амьтдын иймолноор нүүдэллэх үзэгдлийн учир шалтгааныг зөвхөн өнгөц байдлаар л тодорхойлж болно. Бид хиймэл дагуулын мэдээллийг ашиглан, мөн дээрх үзэгдэлтэй цаг хугацааны хувьд тохиолдлоор таарч хээрийн судалгааг явуулан, боломжит таамаглалыг дэвшүүлэн судлав. Судалгаагаар цагаан зээр ОХУ-ын нутагт нэвтрэхээр улсын хил орчимд тулж ирээд байх үед сансрын долгион дамжуулагч бүхий зээр мөн Хятадын нутаг руу гарахаар улсын хилд тулж ирсэн байлаа. Ургамлын бүтээмжийн үнэлгээг сансрын зургийн мэдээлэлд үндэслэн тодорхойлоход Монголын хээрийн ургамлын ногоон масс 10 жилийн турш эрс багассан нь цагаан зээрийн Монголоос гадагш нүүдэллэн шилжих нөхцөл болсон нь тогтоогдов. Ган гачигт байнга нэрвэгдэх болсон хээрийн ландшафтад цаашид ч амьтдын хил дамнасан нүүдэл шилжилт явагдах нь тодорхой бөгөөд иймд хилийн торон хамгаалалтыг бага зэрэг өөрчлөх замаар зээрийн нүүдэллэн амьдрахад шаардлагатай нөхцлийг хангах боломжтой юм.

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